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NOTES ON SOME AUSTRALIAN AND INDO-PACIFIC
ECHINODERMS.

BY HUBERT LYMAN CLARK.

WITH ONE PLATE.

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No. 7. — *Notes on some Australian and Indo-Pacific Echinoderms.* By HUBERT LYMAN CLARK.

The Trustees of the Australian Museum having placed in my hands the collection of echinoderms made by the "Thetis" in 1898, it has seemed desirable before studying that collection to work over the Australian material in the M. C. Z. collections and to describe the new forms. I have to thank Mr. Robert Etheridge, Curator of the Museum, for his courteous approval of this plan. I have found that the ophiurans of the genera *Pectinura* and *Ophiopeza* offer some peculiar difficulties and it has been necessary to make a very careful study of those genera and their allies. This has led to a complete revision of all the known species of ophiurans of that group (which may be styled *Ophiarachna sensu* Müller and Troschel + *Ophiopeza sensu* Peters), and I incorporate my results in this paper.

ASTEROIDEA.

ASTROPECTINIDAE.

Astropecten.

The M. C. Z. collection contains half a dozen *Astropectens* from the coast of New South Wales. Two of these are without doubt *A. polyacanthus* M. and T., but the other four are less easy to determine. One was received in exchange from the United States National Museum and is labelled "*Astropecten triseriatus* M. & T., Botany Bay, Australia." The other three are undoubtedly the same species and are so labelled, but were received from the Australian Museum, and were collected off Port Jackson. These specimens agree well with Müller's and Troschel's description of *A. triseriatus*, except in the most important point. The large spines on the supramarginal plates are in a single series and there is no trace of the second and third series, characteristic of Müller's and Troschel's species, except that on a very few plates a second small spine is present close beside the principal one. I see no reason to doubt that this is the *A. triseriatus* of Whitelegge's list (Journ. Roy. Soc. N. S. W., 23, p. 200), but that it is the *A. triseriatus* of Müller and Troschel seems to me very doubtful. Except for the fact that the ventral and marginal spines are strongly flattened instead of being cylindrical, I should have no hesitation in referring these specimens to Sladen's *A. acanthifer* from the Banda Sea, but the difference in the spines is so marked I hardly think such identification would be correct.

GONIASTERIDÆ.

Goniaster tessellatus.

Asterias tessellata Lamarck, 1816. Anim. s. Vert., 2, p. 552.

Goniaster tessellatus Agassiz, 1835. Mem. Soc. Sci. Neuchatel, 1, p. 191.

As this species has not been recorded from Australia, it may be of interest to note a specimen, labelled "Melbourne, Aust.," which is indistinguishable from those taken at Zanzibar.

Goniodiscaster, nom. nov.

Fisher (1906, Starfishes Haw. Isl., p. 1070) has proposed the name *Goniodiscides* for a group of starfishes, long known as *Goniodiscus*. Fisher shows that the name *Goniodiscus* is untenable, but in order to disturb nomenclature as little as possible, he altered only the termination. Unfortunately, however, he selected for his type the well-known species, *Goniodiscus sebae*, which I have recently shown (Bull. M. C. Z., 51, p. 281) is simply the young of *Culecita novae-guineae*, and therefore *Goniodiscides* is a synonym of *Culecita*. I therefore propose the name *Goniodiscaster* with *Asterias pleyadella* Lamarck as the type-species.

Goniodiscaster pleyadella.

Asterias pleyadella Lamarck, 1816. Anim. s. Vert., 2, p. 553.

Pentagonaster validus Bell, 1884. "Alert" Rept., p. 129.

Goniodiscus pleyadella Döderlein, 1896. Semon's Zoöl. Forsch., 5, p. 308, pl. 18, figs. 34-34f.

Goniodiscides pleyadella Fisher, 1906. Starfishes Haw. Isl., p. 1070.

We are so fortunate as to have in the M. C. Z. collection two excellent specimens of "*Pentagonaster validus*" Bell, which were received in exchange from the British Museum. After a careful comparison of these specimens with Döderlein's (l. c.) excellent photographs, I am satisfied that Bell's species is identical with that which Döderlein calls *G. pleyadella* Lam., so that unless Döderlein is guilty of a serious mistake, Bell's proposed name becomes a synonym of Lamarck's.

Goniodiscaster coppingeri.

Pentagonaster coppingeri, Bell 1884. "Alert" Rept., p. 128.

There is a specimen in the M. C. Z. collection from Adolphus Island, near Cape York, Australia, with rays 72 mm. long, which differs from Bell's description only in color. It is deep brick-red and has apparently never been in alcohol. The species is very distinct from the preceding, but appears to be congeneric with it.

LINCKIIDAE.

Hacelia helicostichus.

"*Linckia nodosa* Perrier" Bell, 1884. "Alert" Rept., p. 124.

Ophidiaster helicostichus Sladen, 1889. "Challenger" Ast., p. 405, pl. 69, figs. 5-7.

Among the starfishes received in exchange from the British Museum, in 1907, is a handsome specimen labelled "*Linckia nodosa*." It is from Prince of Wales Channel, Torres Strait, 7 fms., was collected by the "Alert," and has the rays 118 mm. long. It must be therefore one of those referred to by Bell (l. c.) in the "Alert" Report. Comparison with a specimen of *L. nodosa* of about the same size, labelled by Perrier, shows, what a careful reading of Perrier's description clearly indicates, that the two species are not even congeneric. The Torres Strait specimen is evidently a fine example of Sladen's *Ophidiaster helicostichus*, which was taken by the "Challenger" in Torres Strait. Our specimen has the rays wider at the base than is shown in Sladen's figure, but otherwise shows no peculiarities. The tips of the rays have a bluish tinge which may indicate that the species in life is blue, like *Linckia laevigata*. There can be no question, I think, that this species is congeneric with *Hacelia attenuata* Gray of the Mediterranean.

OPHIUROIDEA.

OPHIODERMATIDAE.

The Genera *Ophiarachna* s. lat. and *Ophiopeza*.

The genus *Ophiarachna* Müller and Troschel was established in 1842 with four species, one of which (*O. incrassata* Lamk.) was readily distinguishable from the others (*O. gorgonia*, *O. infernalis*, and *O. septemspinosa*) by its few, long, stout arm-spines and concealed radial shields. The same year the genus *Pectinura* was established by Forbes for a very small ophiuran (*P. vestita*) from the Ægean Sea, which would naturally have gone in *Ophiarachna* had Forbes known of the existence of that genus. In 1851 Peters established *Ophiopeza* for a species (*O. fallax*) from Mozambique, distinguished from *Ophiarachna* and *Pectinura* by the lack of supplementary oral plates. In 1856 Lutken described a second species of *Ophiopeza* (*O. yoldii*) which he subsequently made the type of a new genus, *Ophiopsammus*. Ten years later Ljungman described two new *Ophiarachnas*, one (*O. spinosa*) from Fua, Tonga Islands, the other (*O. stellata*) from Singapore. The next year Grube redescribed the latter under the name *Ophiolepis* (*Ophiochasma*) *adspersa*. In 1869 Lütken made the first attempt at a revision of the group, removing from *Ophiarachna* *O. gorgonia*, *O. infernalis*, and *O. septemspinosa*, leaving *O. incrassata* as type of the genus and adding a new species (*O. affinis*) thereto. He went still further and separated *Ophiarachna* from its former ally, *Pectinura*, to which he had added several species, and associated it with *Ophiocoma* instead. He refers to the fact that the character which was sup-

posed to distinguish *Ophiopeza* from *Pectinura* (*i. e.* the absence of supplementary oral plates) is not constant, as he found specimens of *Ophiopeza* which had one or more such plates.

In 1872 Ljungman adopted most of Lütken's suggestions but added two new genera (for which, however, he unfortunately failed to designate types), one (*Ophiopezella*) appears to be for his species, *O. spinosa*, and the other (*Ophiarachnella*) for *O. gorgonia* (and possibly *O. infernalis* and *O. septemspinosa*). Lyman never accepted either of Ljungman's genera, or Grube's *Ophiochasma*, or Lütken's *Ophiosammus*, but he followed Lütken's lead as regards *Ophiarachna*'s association with *Ophiocoma*, and in recognizing the two genera *Pectinura* and *Ophiopeza*. He, however, refers several times to the unsatisfactory nature of the character which was supposed to distinguish the two latter. Except for the recognition of *Ophiopezella* by de Loriol and Koehler, Lyman's classification has been used with scarcely any modifications down to the present day. Several writers have referred to the inconstancy of the presence or absence of supplementary oral plates, but no one has ventured to attempt a different grouping of the species. De Loriol, some years ago, called attention to the close resemblance between *Pectinura* and *Ophiarachna*, but it has apparently been agreed that such resemblance was simply parallelism and not an indication of relationship.

Taking up the question *de novo*, I have been forced to the conclusion that Lütken's separation of *Ophiarachna* from the *Pectinura* group and its association with *Ophiocoma* was unfortunate, and can only be rectified by a complete return to the position of Müller and Troschel that *O. incrassata* is closely allied to *O. gorgonia* and its allies. If we consider the morphological characters of the three genera concerned we find that they all have the disc covered with scales, which are concealed by a close granulation that often covers the radial shields and may even extend out a little way on the arms. In *Ophiocoma* and its allies the arm-spines arise from a ridge occupying approximately the vertical mid-line of the side arm-plate, and they stand out at nearly a right angle from the surface of the plate. In *Pectinura* and its allies the arm-spines arise from the distal margin of the side arm-plate and are generally more or less flattened and appressed to the arm; not infrequently there are notches in the proximal margin of the next plate into which they may fit. At first sight the arm-spines in *Ophiarachna* appear to be of the *Ophiocoma* type, for they are long and thick and often stand out at a decided angle from the arm. It was mainly on the strength of this character that Lütken and Lyman agreed on the association of *Ophiarachna* with *Ophiocoma*, but a careful examination of the genera concerned has satisfied me that even in its arm-spine arrangement *Ophiarachna* is nearly allied to *Pectinura*. While there is, in most specimens, a distinct ridge from which the spines arise, it does not occupy the median part of the plate as in *Ophiocoma*, but is really only the thickened distal margin of the plate; and furthermore, in many, if not in all cases, the proximal margin of each side arm-plate shows notches like those found in *Pectinura*. It is clear then that in *Ophiarachna* we have a genus allied to *Pectinura*, in which the increase in size of the arm-spines has led to a super-

ficial resemblance to *Ophiocoma*. Such species of *Pectinura* as *P. septemspinosa*, with its greatly elongated lowest spine, and of *Ophiopeza*, as *O. danbyi*, with its four, long, thick arm-spines, indicate clearly how such a group might arise.

The evidence afforded by the arm-spines is strongly confirmed when we take into account the other morphological characters of the genera concerned. De Loriol long ago called attention to the fact that in some way a serious error has slipped into the diagnosis of *Ophiarachna*, for Lyman and others have said that the genus was characterized (as is *Ophiocoma*) by a cluster of tooth-papillae at the apex of the jaw. As a matter of fact *Ophiarachna* differs sharply from *Ophiocoma* in this particular; there are no tooth-papillae, but the teeth and oral papillae are strikingly like those of *Pectinura*. Another error in Lyman's diagnosis of *Ophiarachna* is the statement, "one or two tentacle-scales." As a matter of fact there are always two tentacle-scales, and they are arranged as in *Pectinura* and its allies, with the outer one overlapping the base of the lowest arm-spine. In *Ophiocoma* and its allies, on the other hand, if two tentacle-scales are present, the outer one does not overlap the base of an arm-spine.¹ The internal anatomy of the jaw-frames, moreover, is, in *Ophiarachna*, like that of *Ophiopeza* and quite different from that of *Ophiocoma* (see p. 127). In the presence of supplementary oral plates and of pores between the basal under arm-plates, *Ophiarachna* differs markedly from *Ophiocoma* and shows a strong resemblance to several species of *Pectinura*.

In consideration of all these facts, it seems clear that *Ophiarachna* is a nearly ally of *Pectinura*, with the arm-spines showing an interesting parallelism to *Ophiocoma*. Indeed it is by no means easy to point out any character or group of characters by which all the species of *Ophiarachna* can be readily separated from all the species of *Pectinura* and *Ophiopeza*.

Another conclusion to which my investigations have led is that the complaints which have arisen from time to time in regard to the inconstancy of the difference between *Pectinura* and *Ophiopeza* are well grounded, and that the two genera cannot be distinguished by the presence or absence of the supplementary oral plates. I have before me two excellent specimens of *Pectinura maculata* Verrill, in one of which the supplementary plates are well developed, while in the other they are wholly wanting. On the other hand, *Ophiopeza fallax* Peters has long been known to vary greatly in this respect, some specimens showing one or more of the supplementary plates. The specimens of *Ophiopeza cylindrica* Hutton, which are accessible, are all *Pectinuras* in this particular, for one has one, one has four, and one has five supplementary plates. Moreover in several of the deep-sea species which have been referred to *Pectinura*, the supplementary plates

¹ Troschel (1879, Sitzungsber. Niederrhein. Gesellsch. Bonn, p. 137) gives a diagnosis of *Ophiarachna* in which he distinctly says "keine Zahnpapillen" and "Schuppen an den Tentakel-poren." Lütken (1869, Add. Hist. Oph., 3, p. 74) says, "To fodpapiller" but does not mention tooth-papillae. Lyman (1882, "Challenger" Oph., p. 173) says, "very numerous, close-set tooth-papillae," and "one or two tentacle-scales."

are so rudimentary that it becomes a question of mere personal opinion whether they are present or not. It seems therefore very unwise to attempt to maintain any longer the artificial line which has so long separated Ophiopeza from Pectinura. Since the latter genus was established, no less than 34 species have been referred to it; of these, *P. forbesi* Heller has been made the type of Ophiocnis by Lütken, *P. spinosa* Ljungman is the type of Ophiopezella, and *P. verrucosa* Studer has been removed to Ophioglypha by Studer himself; as at present recognized then Pectinura contains 31 species. To Ophiopeza 11 species have been referred, but one of these, *O. custos* Koehler, has been transferred by Koehler himself to Ophioplax, so that there are at present 10 species in the genus. If the old distinction between Pectinura and Ophiopeza is abandoned, the question arises are these 41 species congeneric? By no means; for with one or two exceptions, they fall very naturally into five groups, regardless of the presence or absence of supplementary oral plates and of the equally inconstant character, pores between the basal under arm-plates. Curiously enough the number and arrangement of the tentacle-scales, a feature which in some other groups is so variable that it is of doubtful value even for distinguishing species, is here remarkably constant, and is so obvious as to make a very serviceable character. Of the 41 species under consideration only eight have a single, conspicuous tentacle-scale, while the remainder have two, the outer one overlapping the base of the lowest arm-spine. Of the eight species with the single scale, one is unique in having the whole oral surface, including the oral-shields, covered with a fine granulation; the other seven (with perhaps one exception) form a homogeneous and natural group of deep-water species. Of the 33 species having two tentacle-scales ten, including the type of Pectinura, have the radial shields concealed by the granulation of the disc, and as this appears to be a very constant character the name should be restricted to this group. One of the remaining species is quite unique in its very large, bare, radial shields and wide arm-bases, and as it has twice been made a generic type, it may well stand by itself. For the rest of the 22 species, Ljungman's old name Ophiarachnella is available and should be used. The chief objection to this grouping is that Peter's familiar name Ophiopeza becomes a synonym of Pectinura. It is unfortunate, but in view of the inconstancy of the character upon which the genus is based, this result cannot be avoided.

In the examination of the M. C. Z. collection, I have found two undescribed species of this group. I have also found that some of the hitherto unrecognized species cannot be maintained. I give therefore the following artificial key to the genera which have been under discussion, and a list of the valid species under each genus with artificial keys to the same. The essential synonymy of each genus and species is also included.

Key to the Genera.

Oral shields distinct, not concealed by any granulation.

Tentacle-scales 2, at least on basal part of arm, with outer overlapping base of lowest arm-spine.

- Arm-spines short, rarely (except lowest) exceeding joint (in *Pectinura danbyi* nearly twice as long as joint) more or less closely appressed to arm.
- Radial shields covered by granulation of disc.
 Disc more or less notched at insertion of arm; marginal scales not enlarged or visible through granulation . . . *Pectinura*
 Disc not notched at insertion of arms; marginal scales enlarged, conspicuous underneath granulation . . . *Ophiopezella*
- Radial shields not covered by granulation of disc.
 Radial shields very large; interradial space between two little wider than radial; interbrachial areas (orally) narrower than arm-bases . . . *Ophiochasma*
 Radial shields small or of moderate size; interradial space between two much wider than radial; interbrachial areas (orally) wider than arm-bases . . . *Ophiarachnella*
- Arm-spines long, 1-3 times as long as joint, more or less flaring; supplementary oral plates present in interbrachial areas . . . *Ophiarachna*
- Tentacle-scale single, very large (one or two additional may be present on some basal pores); supplementary oral plates rudimentary or wholly wanting . . . *Bathypectinura*
- Oral shields more or less completely concealed by granulation of interbrachial area; tentacle-scale single; arm-spines very short, appressed . . . *Cryptopelta*

Pectinura.

Forbes, 1842. Trans. Linn. Soc., London, 19, p. 143.

Type-species, *vestita* Forbes, l. c. Monotypic at the time.

Synonyms: *Ophiopeza* Peters, 1851. Monatsb. Kön. Ak. Berlin, p. 465. Based on *O. fallax* Peters (l. c.) and supposed to be distinguished by absence of supplementary oral plates. This character having been shown to lack generic value, *O. fallax* is here placed, because of its hidden radial shields, in *Pectinura*; *Ophiopeza* thus becomes a pure synonym.

Ophiopsammus Lütken, 1869. Add. Hist. Oph., 3, p. 37. Based on *Ophiopeza yoldii* Lütken (1859, Add. Hist. Oph., 2, p. 98) and supposed to be distinguished by absence of supplementary oral plates and concealment of radial shields. The species *O. yoldii* thus belongs in *Pectinura* as here used, and *Ophiopsammus* becomes superfluous.

There can be no question as to the type-species of this genus, but unfortunately, owing to the fact that it has not been met with since Forbes secured his single small specimen, there is some room for doubt as to whether the radial shields in that species are covered by the granulation of the disc or not. So far as I can judge from Forbes's description and figure, the radial shields are not to be distinguished, save with difficulty, from the ordinary disc-scales, and like them are

covered with granules. Should it be shown hereafter that this interpretation is incorrect, and the radial shields are free from granules, then *P. vestita* belongs in the genus here called Ophiarachnella, which then becomes Pectinura, while Pectinura, as here used, would then take the name Ophiopeza Peters, since the type *O. fallax* is a typical member of this group.

This is a natural and, except for *P. danbyi*, a very homogeneous group of shallow-water forms, confined to the eastern Mediterranean, Indian Ocean, East Indies, Australia, and New Zealand. They are to be distinguished from each other chiefly by the number, length, and appearance of the arm-spines, but the granulation of the disc and the form of the upper and under arm-plates may furnish excellent characters.

Key to the Species of Pectinura.

Arm-spines blunt, or slightly acute, middle ones not longest.

Arm-spines few (4-8).

Arm-spines 6-8.

Upper arm-plates "somewhat orbicular;" under arm-plates fan-shaped; arm-spines about as long as joint *vestita*

Upper arm-plates at first squarish, becoming fan-shaped on outer part of arm; under arm-plates not fan-shaped; arm-spines about $\frac{2}{3}$ joint *cylindrica*

Arm-spines fewer.

Arm-spines 5, about $\frac{2}{3}$ joint *exilis*

Arm-spines 4, nearly twice as long as joint *danbyi*

Arm-spines numerous (9-14).

Disc granulations coarse (35-200 per sq. mm.); arm-spines $\frac{1}{2}$ joint or longer.

Upper arm-plates not twice as wide as long; supplementary oral plates well marked; arm-spines about $\frac{1}{2}$ joint, lowest distinctly longest *arenosa*

Upper arm-plates three times as wide as long or wider; supplementary oral plates often wanting.

Size large, disc diameter up to 40 mm.; arms conspicuously spotted with purple; oral shields usually longer than wide; lowest arm-spines largest but not necessarily longest *maculata*

Size smaller, disc diameter seldom up to 25 mm.; arms not at all spotted or marked with purple.

Arm-spines subequal; oral shields rather wider than long *assimilis*

Lowest arm-spine decidedly longest; oral shields about as long as wide *aequalis*

Disc granulations very fine (350-500 per sq. mm.); arm-spines scarcely $\frac{1}{2}$ joint *fallax*

Arm-spines sharp, middle ones distinctly longest *yoldii*

Pectinura vestita.

Forbes, 1843. Trans. Linn. Soc. London, **19**, p. 143, pl. 13, figs. 1-7.

Coast of Lycia, Asia Minor, 100 fms.

This species has not been met with since Forbes collected his single specimen, "among corallines" on the coast of Asia Minor, nearly seventy years ago. That specimen was obviously young, having a disc only 2-3 mm. across, and there is room for considerable speculation as to what the adult might reveal as to the real relationship of the species.

Pectinura cylindrica.

Ophiura cylindrica Hutton, 1872. Cat. N. Z. Ech., p. 3.

Ophiopeza cylindrica Farquhar, 1895. Trans. and Proc. N. Z. Inst., **27**, p. 198.

New Zealand. Littoral.

Of three specimens in the M. C. Z. collection, one has five supplementary oral plates, one has four, and one has one. According to Farquhar (l. c.), there are none. Except between the first and second under arm-plates on one arm of one specimen, there are no arm-pores in the M. C. Z. specimens.

Pectinura exilis.

Ophiopeza exilis Koehler, 1905. Oph. "Siboga:" Litt., p. 12, pl. 2, figs. 5, 6, and 8.

Near Tanah, Waigiou, and Kei Islands, D. E. I., 46-222 fms.

It is most unfortunate that figures 5 and 7 of Koehler's plate are transposed, presumably by a slip of the pen. It is stated in the text, on the bottom of the plate (2) and on the explanatory page opposite, that figs. 6-8 are *Ophiopeza exilis*, but a little observation and comparison of the figures and descriptions shows that fig. 7 is *Ophioconis permixta*, while fig. 5, said to be that species, is really *Ophiopeza exilis*.

Pectinura danbyi.

Ophiopeza danbyi Farquhar, 1897. Journ. Linn. Soc. London, **26**, p. 189, pl. 14, figs. 7, 8.

Raoul Island, Kermadecs, N. Z.

The single known specimen of this species is notable for its arm-spines, which show a decided resemblance in number, length, and form, to those of *Ophiarachna*.

Pectinura arenosa.

Pectinura arenosa Lyman, 1879. Bull. M. C. Z., **6**, p. 48, pl. 14, figs. 392-394. 1882, "Challenger" Oph., p. 15, pl. 23, figs. 10-12.

Off East Moncur Island, Bass Strait, Australia, 33 fms.; Thursday Island, Torres Strait; Point de Galle, Ceylon, 34 fms.

Pectinura maculata.

Ophiarachna maculata Verrill, 1869. Proc. Boston Soc. Nat. Hist., **12**, p. 388.

Pectinura maculata Verrill, 1869. Amer. Journ. Sci., (2) **48**, p. 431 (footnote).

New Zealand. Littoral.

Of three specimens in the M. C. Z. collection, one (disc diameter 41 mm.) has five small but distinct supplementary oral plates; a second (disc diameter 30 mm.) shows one very narrow supplementary oral plate, but the lower surface of the disc is so badly damaged it is impossible to decide positively whether this was the only one present or not; the third (disc diameter 17 mm.) has not the slightest trace of such supplementary plates. Pores seem to be constantly present between the first and second under arm-plates, but in the smallest specimen they can scarcely be seen on two of the arms.

Pectinura assimilis.

Ophiopeza assimilis Bell, 1888. Proc. Zool. Soc. London, p. 282, pl. 16, fig. 5.

Port Jackson, N. S. W.

As this species does not seem to have been met with since its original description was published, it is a pleasure to record a specimen in good condition in the M. C. Z. collection with the disc 25 mm. in diameter. This specimen was acquired by purchase and bears the label "South Australia?" The arms are only about 75 mm. in length and are thus only three times the diameter of the disc. The granulation of the disc is coarser than in Bell's type, as I find only six or seven grains to a millimeter, while he counted nine. The M. C. Z. specimen has apparently never been in alcohol, or at most only for a short time, for in its dry condition the colors are so distinct they must show very nearly the appearance of life. The disc is pale brown, distinctly marked with an irregular star of tawny-brown, each ray of which continues out onto the basal joints of the arm. The lower surface of the disc is yellowish-brown, with the oral shields somewhat darker. The arms, seen from above, are banded with dirty-whitish, the ground color being tawny-brown. Bell's description would indicate a somewhat different coloration for his specimen, which, however, was apparently an alcoholic one. There appears to be a slip of the pen in Bell's description with reference to the measurements. He says the arms are "about four and a half times" the diameter of disc, and then he gives the following measurements: "Diam. of disc 100 (ea.) mm.; length of arms 24 mm." This may mean that the disc is 24 and the arms 100 mm., or possibly the "100" is a misprint for 10 and the "24" a misprint for 42, but in either case the arms would be only four times the disc diameter.

Pectinura aequalis.

Ophiopeza aequalis Lyman, 1880. Anniv. Mem. Boston Soc. Nat. Hist., p. 9, pl. 2, figs. 23-25. 1882, "Challenger" Oph., p. 12, pl. 27, figs. 7-9.

Northeast of New Guinea, 150 fms.; west of Kei Islands, 114 fms.

Pectinura fallax.

Ophiopeza fallax Peters, 1851. Monatsb. Kön. Ak. Berlin, p. 465.

Querimba and Zanzibar, East Africa; Madagascar; Amboina; "Great Ocean." Littoral.

Of eight specimens from Zanzibar in the M. C. Z. collection, one has *six* arms; another has a supplementary oral plate; another has two such plates; the remainder have none.

Pectinura yoldii.

Ophiopeza yoldii Lütken, 1856. Vid. Med., p. 9.

Ophiopsammus yoldii Lütken, 1869. Add. Hist. Oph., 3, p. 37.

Ophiopeza conjungens Bell, 1884. "Alert" Rept., p. 137.

New South Wales; Queensland; Thursday Island, Torres Strait; off Sumbawa and Waigiou, D. E. I.; "Indian Ocean;" Pandanao, Philippines; Sumatra. Littoral to 120 (385?) fms.

As the M. C. Z. collection contains a specimen of *P. yoldii* identified by Lyman after examination of the type at Copenhagen, and a specimen of *P. conjungens* from Port Molle, Queensland, identified by Bell, I have been able to satisfy myself that the two names refer to the same species. The form and relative lengths of the arm-spines are very characteristic, while their number varies from 5 to 10 according to the size of the specimen; an adult specimen (disc diameter about 12 mm.) will have 7 or 8 arm-spines on most of the basal joints. Verrill (1899, Trans. Conn. Acad. 10, p. 373) gives *P. yoldii* as occurring in shallow water in the West Indian region. I have been unable to find any record of this species having been taken anywhere in the western hemisphere. I presume, therefore, that Verrill's statement rests on Lütken's original record; but Lütken does not say that the type-specimen was from the West Indies; he simply says that it was probably West Indian, though the locality on the label (Antillerne) he admits is hypothetical.

Ophiopezella.

Ljungman, 1872. Öfv. Kongl. Vet.-Ak. Förh., 28, p. 639.

Type *O. spinosa* (*Ophiarachna*) Ljungman, 1867. Öfv. Kongl. Vet.-Ak. Förh., 23, p. 305. Monotypic at the time.

This genus failed to meet with Lyman's approval, but it has been revived by de Loriol (1893, Rev. Suisse de Zoöl., 1, p. 392; pl. 13, figs. 1-1e) and really seems entitled to recognition. Ljungman does not designate any type but says the genus is equivalent to "Ophiopeza Ltk., *non* Peters, *nec* Lym.; Ophiarachna Ljn. ex parte." But "Ophiopeza Ltk." (Add. Hist. Oph., 3, p. 35) was based on two specimens of an ophiuran from Fiji which Lütken considered identical with *Ophiopeza fallax* Peters and also with *Ophiarachna spinosa* Ljungman. Ljungman recognized from Lütken's account that the specimens were not *O. fallax*, but

were *O. spinosa*, and de Loriol (l. c.) has confirmed Ljungman's statement that Lütken's *Ophiopeza* was therefore not the same as Peters's. Moreover *O. spinosa* is the only species in *Ophiarachna* as used by Ljungman in 1866 to which the diagnosis of *Ophiopezella* will apply, and it must therefore be the type of the genus. The reasons given by de Loriol (l. c.) for considering Lütken's specimens from Fiji and his own from Amboina distinct from Ljungman's appear very trivial, and I have no doubt that they are *O. spinosa*. There are, however, two species in the genus, and they may be distinguished as follows:

Arm-spines 12-14; color brown	<i>spinosa</i>
Arm-spines 9; color yellowish-green	<i>dubiosa</i>

Ophiopezella spinosa.

Ophiarachna spinosa Ljungman, 1867. Öfv. Kongl. Vet.-Ak. Förh., **23**, p. 305.

"*Ophiopeza fallax* Peters" Lütken, 1869. Add. Hist. Öph., **3**, p. 35.

Pectinura spinosa Lyman, 1874. Bull. M. C. Z., **3**, p. 221.

"*Ophiopezella spinosa* Ljn." Lyman, 1882. "Challenger" Oph., p. 17.

Ophiopezella Lütkeni de Loriol, 1893. Rev. Suisse de Zool., **1**, p. 392, pl. 13, figs. 1-1 e.

Fua, Tonga Islands; Fiji Islands; Amboina; Society Islands. Littoral.

There are three specimens in the M. C. Z. collection identified by Lyman, and agreeing well with Ljungman's and Lütken's descriptions. They also agree in all essentials with de Loriol's description and figures.

Ophiopezella dubiosa.

Ophiopezella dubiosa de Loriol, 1894. Mem. Soc. Phys. et Hist. Nat. Genève, **32**, pt. 1, no. 3, p. 7, pl. 23, figs. 2-2 f.

Mauritius Littoral.

Ophiochasma.

Grube, 1868. 45th Jahres-Bericht d. Schles. Gesell., p. 45.

Type *O. adspersa* Grube, l. c. (= *Ophiarachna stellata* Ljn.). Monotypic at the time.

Synonym: *Ophiopinax* Bell, 1884. "Alert" Rept., p. 135. Based on *Pectinura stellata* Lyman, and consequently having the same type as, and being co-extensive with, Grube's genus. Since Lyman (1874, Bull. M. C. Z., **3**, p. 221) had called attention to Grube's proposed genus and shown that its type was identical with *O. stellata*, it seems strange that Bell should have considered a new name necessary; for, though Grube proposed *Ophiochasma* as a subgenus of *Ophiolepis*, that does not affect its validity as a generic name (Generic and subgeneric names are . . . from a nomenclatural standpoint . . . of the same value. Int. Code, Art. 6).

Although Lyman regarded this genus as quite superfluous, I agree with Bell that it deserves recognition, for the differentiation of the species on which it is based has gone so much further than in its nearest allies that there is a very distinct gap between it and them.

Ophiochasma stellata.

Ophiarachna stellata Ljungman, 1867. Öfv. Kongl. Vet.-Ak. Förh., **23**, p. 305.

Ophiolepis adspersa Grube, 1868. 45th Jahres-Bericht d. Schles. Gesell., p. 44.

Ophiolepis (*Ophiochasma*) *adspersa* Grube, l. c., p. 45.

Pectinura stellata Lütken, 1869. Add. Hist. Oph., **3**, p. 33.

"*Ophiochasma* (*Ophiolepis*) *adspersum* Grube" Lyman, 1882. "Challenger" Oph., p. 15.

"*Ophiarachnella stellata* Ljn." Lyman, l. c.

Ophiopinax stellatus Bell, 1884. "Alert" Rept., p. 136, pl. 8, fig. C.

Singapore; East Indies; Philippine Islands; Queensland; Torres Straits; Gulf of Siam. Littoral.

Ophiarachnella.

Ljungman, 1872. Öfv. Kongl. Vet.-Ak. Förh., **23**, p. 640.

Type, *O. gorgonia* (*Ophiarachna*) Müller and Troschel, 1842. Sys. Ast., p. 105.

Unfortunately Ljungman failed to designate any type, his only statement being "Pectinura Ltk.; Ophiarachna M. Tr. ex parte." But Lütken (1869, Add. Hist. Oph., **3**, p. 33) had definitely restricted Pectinura to *P. vestita* Forbes, *P. stellata* Ljungman, and *P. gorgonia* Müller and Troschel;¹ and since *P. gorgonia* is the only one of these of which it can be said in any sense "Ophiarachna M. Tr. ex parte," it seems clear that that species must be the type of Ophiarachnella. Lyman evidently considered *P. stellata* the generic type, for he gives as a synonym of *Pectinura stellata*, "*Ophiarachnella stellata* Ljn., Dr. Goës, Oph. Öfv. Kongl. Akad., p. 640, 1871" ("Challenger" Oph., p. 15). But if Ljungman had intended *P. stellata* to be the type-species, he would have written "Ophiarachna Ljn. ex parte" instead of "Ophiarachna M. Tr. ex parte." As already stated it seems desirable to use this generic name for the majority of those ophiurans which have hitherto been called Pectinura. The well-known species *P. gorgonia* M. & T. is not only the type, but also fortunately an excellent example of the group, as the radial shields are of moderate size and very distinct, the tentacle-scales are noticeable for their characteristic form and position, and the arm-spines, though above the average in number, are short and appressed. There appear to be at least fourteen other species which belong in the same genus.

Key to the Species of Ophiarachnella.

Radial shields more or less elongate, of moderate or large size (length commonly much more than $\frac{1}{10}$ diameter of disc), usually not darker in color than disc; usually not more than 3 pairs of arm-pores visible.

¹ Lütken's statement concerning *P. infernalis* and *P. septemspinosa* of Müller and Troschel is ambiguous, but it is clear he did not consider them typical of Pectinura. Either, however, might be taken as the type of Ophiarachnella if necessary, as they are congeneric with *P. gorgonia*.

- Upper arm-spines not longest and not equalling joint.
 Arm-spines numerous (8-13).
 Lowest arm-spine not noticeably longer than others and not equalling joint.
 Entire disc granulated, except radial shields; arm-pores present *gorgonia*
 Some other disc-plates bare, besides radial shields; arm-pores wanting *infernalis*
 Lowest arm-spine longest, exceeding joint *angulata*
- Arm-spines few (4-7).
 Arm-spines 4, lowest longest, with tips minutely spinous . . . *paucispina*
 Arm-spines 5-7 (rarely 8), tips not spinous.
 Radial shields small, widely separated, with 1-3 large, bare plates between; arm-spines rarely 8 *sphenisci*
 Radial shields not separated by large bare plates.
 Arms 8-10 times disc-diameter; arm-spines 6, lowest longest and equalling joint; no arm-pores *elegans*
 Arms 4-6 times disc-diameter.
 Radial shields large and conspicuous; distance between two of a pair less than width of one.
 Oral shields as wide as long; arm-spines 7; arms slightly carinated *megaloplax*
 Oral shields decidedly longer than wide; arm-spines 6; arms strongly carinated *nitens*
 Radial shields small; distance between two of a pair greater than width of one.
 Lowest arm-spine decidedly longest, equalling joint.
 Arm-spines 5; arm-pores present *stabilis*
 Arm-spines 6-7; arm-pores wanting *petersi*
 Arm-spines subequal or lowest a trifle larger and rather more than $\frac{1}{2}$ arm-joint.
 Arm-spines 5; upper arm-plates much wider than long; arm-pores wanting *capensis*
 Arm-spines 6-7; upper arm-plates rounded, about as long as wide; arm-pores present *semicineta*
- Arm-spines 7-8, upper ones longest, equalling or exceeding joint, lowest much shorter, blunt; under arm-plates much wider than long; 2 pairs of arm-pores present *honolata*
- Radial shields more or less circular, minute (length commonly much less than $\frac{1}{10}$ diameter of disc), but conspicuous because of their very dark color; more than 4 pairs of arm-pores are usually visible in adult specimens; lowest arm-spines conspicuously longest.
 Arm-spines 7-10, short, wide, flat, white- (or light-) tipped; color nearly uniformly dark; arms banded with whitish or yellowish, or not at all *septemspinosa*
 Arm-spines 7-9, as long as joint, not wide and flat, not white-tipped; color light and dark; arms banded with blackish . . . *macracantha*

Ophiarachnella gorgonia.

- Ophiarachna gorgonia* Müller and Troschel, 1842. Sys. Ast., p. 105.
Pectinura gorgonia Lütken, 1869. Add. Hist. Oph., 3, p. 33.
Pectinura marmorata Lyman, 1874. Bull. M. C. Z., 3, p. 222, pl. 5, figs. 1-7.
Pectinura ramsayi Bell, 1888. Proc. Zool. Soc. London, p. 281, pl. 16, figs. 1, 2.
Pectinura intermedia Bell, 1888. Proc. Zool. Soc. London, p. 386.
Pectinura Stearnsii Ives, 1891. Proc. Acad. Nat. Sci. Philadelphia, p. 212, pl. 11, figs. 1-5.
Pectinura venusta de Loriol, 1894. Mem. Soc. Phys. et Hist. Nat. Genève, 32, pt. 1, no. 3, p. 16, pl. 23, figs. 3-3h.

Natal; Mozambique; Zanzibar; Madagascar; Mauritius; Ceylon; Madras; Pondicherry; Andaman Islands; Nossi-Bé; Tonquin; Pelew Islands; Philippine Islands; southern Japan; Amboina and 15 other stations in Dutch East Indies; Sorong, New Guinea; New Caledonia; Torres Strait; Port Jackson, N. S. W.; Turtle Bay, southern West Australia; Fiji Islands; Gilbert Islands; Samoa. Littoral to 155 fms.

The M. C. Z. collection contains 59 specimens of an ophiuran which, while showing great diversity in size and color, are so alike, or intergrade with each other so completely, in form, proportions, granulation, scaling, arm-plates, oral shields, arm-spines, etc., that I am entirely unable to distinguish more than a single species. This series includes a specimen from Mauritius which answers almost exactly to de Loriol's description and figures of *O. venusta*; Lyman's type and co-types of *O. marmorata* from the Philippines; specimens from Port Jackson, sent by the Australian National Museum, labelled *O. marmorata* (3), *O. ramsayi* (3), and *O. gorgonia* (1); and numerous specimens labelled *O. gorgonia* by Lyman. After a very thorough study of this material, I am unable to satisfy myself that any of the above-named species can be distinguished from *O. gorgonia*. It would be hard to pick out three specimens of *Ophiarachnella* which look more unlike superficially than a typical *O. gorgonia* var. *viridis* Brock, an *O. marmorata* from the Philippines, and an *O. marmorata* from Port Jackson, the coloration is so strikingly different; and yet when one attempts to separate them in any other way than by color and size it proves to be practically impossible. I am therefore forced to the conclusion that the 59 specimens before me represent a single species, very variable in color and size, and showing more or less diversity in its structural characters. Furthermore, I fail to find any character by which *O. intermedia* Bell is to be distinguished, and I believe the type of *O. stearnsii* Ives is simply an exceptionally large individual of the same species. I am confirmed in this opinion by the fact that such a keen observer as Brock collected only *O. gorgonia* during his stay in the East Indies, not finding any specimens which he could separate as *O. marmorata*, aute., and further by the even more remarkable fact that Koehler, in all of the immense amount of material which has passed through his hands in the past twenty years, including the "Investigator" and "Siboga" collections, has not discovered any specimens of *O. marmorata*, aute. to be distinguished from *O. gorgonia*. It is nevertheless quite possible that in the light

of more abundant material it will be shown that some of the species here placed as synonyms of *O. gorgonia* are really entitled to recognition.

Ophiarachnella infernalis.

Ophiarachna infernalis Müller and Troschel, 1842. Sys. Ast., p. 105.

Pectinura infernalis Lütken, 1869. Add. Hist. Oph., 3, p. 33.

Pectinura similis Koehler, 1905. Oph. "Siboga" Litt., p. 6, pl. 1. figs. 4-6.

Indian Ocean; near Sumatra; Philippines; Queensland; Torres Strait; Pelew Islands; Zanzibar; Sorong, New Guinea; Amboina; a dozen "Siboga" stations in the Dutch East Indies. Littoral to 33 fms.

It is with great hesitation that I disagree with so excellent an authority as M. Koehler concerning the distinctive features of this species, but the 37 specimens in the M. C. Z. collections have convinced me that it is not possible to distinguish the form designated by Koehler (l. c.) as *O. similis* from the ordinary *O. infernalis*. The size, number, and position of the bare plates of the disc and the number of arm-spines show so great diversity in the specimens before me that I find it practically impossible to delimit more than a single species. It is true that none of the specimens studied is a typical *O. similis*, but some of them have 11 arm-spines, and others approach that form in the dorsal plates and radial shields. As the "Siboga" twice took *O. similis* and *O. infernalis* at the same station, there is evidently no geographical or bathymetrical line between the two forms.

Ophiarachnella angulata.

Pectinura angulata Lyman, 1883. Bull. M. C. Z., 10, p. 232, pl. 3, figs. 7-9.

West Indies, 88-248 fms.; Bahama Bank.

Koehler (Oph. "Siboga" Mer Prof., p. 9) speaks of *O. angulata* as having "une seule écaille tentaculaire"; this is an unaccountable mistake, for Lyman says distinctly "two tentacle-scales" and the specimens before me show the tentacle-scales to be exactly like those of other species of *Ophiarachnella*.

Ophiarachnella paucispina.

Pectinura paucispina Koehler, 1905. Oph. "Siboga" Litt., p. 4, pl. 1, figs. 13-15.

Strait of Makassar, 20 fms.; off Waigiu, 45 fms.

Ophiarachnella sphenisci.

Pectinura sphenisci Bell, 1894. Proc. Zool. Soc. London, p. 406, pl. 25, figs. 7-9.

Holothuria Bank, N. W. Australia; N. coast of Celebes; near Amboina; off Aru Islands. Littoral to 25 fms.

Koehler (Oph. "Siboga" Litt., p. 10) says that Bell's type was from Macclesfield Bank, while Bell himself says it was from Holothuria Bank. Koehler's very natural mistake is due to the misleading title of Bell's paper.

Ophiarachnella elegans.*Pectinura elegans* Bell, 1894. Proc. Zool. Soc. London, p. 406.

Macclesfield Bank, East Indies, 13-35 fms.

Ophiarachnella megaloplax.*Pectinura megaloplax* Bell, 1884. "Alert" Rept., p. 134.

Port Molle, Queensland, 14 fms.

Ophiarachnella nitens.*Pectinura nitens* Koehler, 1905. Oph. "Siboga" Litt., p. 10, pl. 1, figs. 10-12.

Off Sumbawa, D. E. I., 38 fms.

Ophiarachnella stabilis.*Pectinura stabilis* Koehler, 1905. Oph. "Siboga" Litt., p. 5, pl. 1, figs. 7-9.

Paternoster Islands, 7 fms.; off Waigiou, 45 fms.

Ophiarachnella petersi.*Ophiopeza petersi* Lyman, 1878. Bull. M. C. Z., 5, p. 217, pl. 2, figs. 22-24.Off Cuba, 177 fms.; off Fort Jefferson, Tortugas, Fla., $1\frac{1}{2}$ -8 fms.

Aside from the absence of the supplementary oral plate, this species shows well the characters of the genus. So far as the few known specimens show, the supplementary plates are never clearly marked, but in both of the specimens in the M. C. Z. collection the oral shields bulge out on their distal margin into the inter-brachial areas, and in one area of the larger specimen (Lyman's type) there is a small supplementary plate.

Ophiarachnella capensis.*Pectinura capensis* Bell, 1888. Proc. Zool. Soc. London, p. 282, pl. 16, figs. 3, 4.

Cape of Good Hope.

Ophiarachnella semicineta.*Pectinura semicineta* Studer, 1882. Abh. Königl. Ak. Wiss. Berlin, p. 4, pl. 18, figs. 1-1d.

Vicinity of Cape Verde Islands, 35-58 fms.

Ophiarachnella honorata.*Pectinura honorata* Koehler, 1904. Oph. "Siboga" Mer Prof., p. 8, pl. 2, figs. 1-3.

Vicinity of Kei Islands, 170 fms.

Ophiarachnella septemspinosa.

Ophiarachna septemspinosa Müller and Troschel, 1842. Sys. Ast., p. 105.

Pectinura septemspinosa Lütken, 1869. Add. Hist. Oph., 3, p. 33.

Pectinura rigida Lyman, 1874. Bull. M. C. Z., 3, p. 224.

Ophiarachna armata Troschel, 1879. Sitzungs-b. Niederh. Gesellsch. Bonn, p. 137.

Pectinura armata de Loriol, 1894. Mem. Soc. Phys. et Hist. Nat. Genève, 32, pt. 1, no. 3, p. 13.

Moluccas; Zanzibar; Mauritius; Amboina; Fiji Islands; Ceylon; off Borneo. Littoral to 30 fms.

The specimens in the M. C. Z. collection from Mauritius and Zanzibar, taken in connection with Brock's (Zeit. f. w. Zool., 47, p. 472) and de Loriol's (l. c.) extended descriptions, and Döderlein's (Zool. Jahrb., Sys., 3, p. 830) notes, have satisfied me that Döderlein (Semon's Zool. Forsch., 5, p. 282) is correct in considering *O. armata* too near *O. septemspinosa*, that de Loriol is correct in regarding *O. rigida* as very near *O. armata*, and that Brock is entirely right in placing *O. rigida* as a synonym of *O. septemspinosa*. The three names undoubtedly belong to a single species. Lyman's type of *O. rigida* is a very large, unicolored specimen, but the arm-spines show the characteristic light tips.

Ophiarachnella macracantha, sp. nov.

(Greek μακρός = long + ἀκανθα = spine, in reference to the very long, lowest arm-spine.)

Disc 24 mm. in diameter, pentagonal, distinctly incised at base of each arm; arms about 125 mm. long, nearly 5 mm. wide, and 4 mm. high at base, tapering gradually to the slender tip. Disc (except radial shields) covered with a fairly coarse granulation, about 7 or 8 grains to a millimeter. Radial shields a trifle longer than wide, about 1½ mm. in diameter, very conspicuous. Upper arm-plates about three times as wide as long with fairly straight margins and rounded corners. Under arm-plates at first much wider than long, with very convex distal margin and somewhat concave proximally; further out they gradually become longer than wide. Pairs of pores are very noticeable between each two plates of the first six or eight, and they apparently continue far beyond the middle of the arm. Oral shields rounded with a very indistinct angle inwards, usually wider than long, but one is longer than wide. Side mouth-shields very small, bare. Supplementary oral plates, small and inconspicuous; in one area the supplementary plate is so small and so imperfectly separated from the oral shield it might easily be overlooked. Oral papillae 10-12 on each mouth-angle, flat, rounded, and well-spaced. Mouth-angle terminated by lowest tooth, which is large, flat, and rounded. Arm-spines 8 or sometimes 9, upper and middle ones as long as an arm-joint, somewhat pointed; next to lowest much longer than a joint, bluntly pointed; lowest long and conspicuous, equalling two joints, flat and truncate. Tentacle-scales 2, about equally long and rounded at tip, but outer much wider than inner. Color of disc and arms, above fawn-brown, beneath

lighter, and on interbrachial areas more yellowish; radial shields, deep brown; arms with about a dozen annulations, approximately two joints wide, of dark purplish-brown.

In smaller specimens the disc is not distinctly notched at base of arms; the upper arm-plates are only twice as wide as long; there are only 7 arm-spines and the lowest is only equal to $1\frac{1}{2}$ joints; and there are only 6-10 dark annulations on the arms. One specimen has the ground color a much darker brown than the others.

Pouape, Caroline Islands. Rev. A. A. Sturgis coll. Three specimens. The specimens were labelled by Mr. Lyman: "Pectinura septemspinosa? Probably same as unique original at Leyden. Differs 1. Longer arm-spines. 2. Rather finer granulation. 3. Upper arm-plates not broken." Since Mr. Lyman wrote that label *O. septemspinosa* has been found abundantly at Amboina, Ceylon, and Mauritius, and has been fully described and its variations discussed by Brock (l. c.), Döderlein (l. c.), and de Loriol (l. c.). In the light of our present knowledge, it seems impossible to consider these specimens from the Caroline Islands as belonging to *O. septemspinosa* or any other described species.

Ophiarachna.

Müller and Troschel, 1842. Sys. Ast., p. xiii, 84, 104.

Type, *O. incrassata* Müller and Troschel, l. c. Selected by Lütken, 1869. Add. Hist. Oph., 3, p. 33.

It is hard to understand why Lütken and Lyman should have considered this genus closely allied to *Ophiocoma*. If one ignores the length of the arm-spines, it is not easy to point out a single character by which *Ophiarachna* can be separated from *Pectinura*. I am unable to see that the *position* of the spines on the side arm-plate is essentially different even in *Ophiocoma* from what it is in *Pectinura*; it seems to be simply a difference in the size of the spines. Lyman ("Challenger" Oph., p. 173) has pointed out the very important difference between *Ophiarachna* and *Ophiocoma*, in the structure of the "peristomial plate," but he fails to note that *Ophiarachna* strongly resembles *Ophiopeza* and the other *Ophiodermatidae* in that feature. Lyman says that in all other particulars the skeleton resembles that of *Ophiocoma*, but the same is true of the *Ophiodermatidae* in general, so that it is no argument in support of associating *Ophiarachna* with *Ophiocoma*.

As limited by Lütken and in the sense in which the name is now universally used *Ophiarachna* includes four species.

Key to the Species of *Ophiarachna*.

Radial shields concealed by granulation of disc.

Arm-spines 4, very rarely 5, on a few basal joints; colors chiefly yellow or greenish *incrassata*

Arm-spines 5-7, rarely 4; colors chiefly brown of some dark shade.

Oral shields wider than long; disc brown and yellowish; arms annulated	<i>affinis</i>
Oral shields longer than wide; disc uniform, deep brown; arms not annulated	<i>mauritiensis</i>
Radial shields bare; disc brown, more or less variegated with yellow; arm-spines 4-5	<i>robillardii</i>

Ophiarachna incrassata.

Ophiura incrassata Lamareck, 1816. Anim. sans Vert., **2**, p. 542.

Ophiarachna incrassata Müller and Troschel, 1842. Sys. Ast., p. 104.

Java; Pelew Islands; Philippines; New Britain; Amboina; Timor; half a dozen "Siboga" stations in D. E. I.; "Sea of Bengal;" Ceylon; Zanzibar; Darros Island; "intertropical Australia." Littoral to 20 fms.

A specimen in the M. C. Z. collection measures 56 mm. across the disc and is the largest simple-armed ophiuran of which I can find any record.

Ophiarachna affinis.

Ophiarachna affinis Lütken, 1869. Add. Hist. Oph., **3**, p. 33.

Ophiarachna clavigera Brock, 1888. Zeits. f. w. Zool., **47**, p. 47.

Fiji Islands; Samoa; Amboina; Fernando Veloso, Mozambique. Littoral.

Both de Loriol (Rev. Suisse de Zool., **1**, p. 411) and Koehler (Mem. Soc. Zool. France, **17**, p. 76) are agreed that *O. clavigera* Brock is a synonym of *O. affinis*, and I see no reason to doubt their decision. It does seem doubtful, however, whether the specimen recorded by Koehler (Bull. Sci. France et Belgique, **41**, p. 330) from Fernando Veloso, with only 3-4 arm-spines, is really *O. affinis*. The locality and the very small number of arm-spines cause one to be suspicious.

Ophiarachna mauritiensis.

Ophiarachna mauritiensis de Loriol, 1894. Mem. Soc. Phys. et Hist. Nat. Genève, **32**, pt. 1, no. 3, p. 32, pl. 24, figs. 1-1e.

Mauritius.

Ophiarachna robillardii.

Ophiarachna robillardii de Loriol, 1894. Mem. Soc. Phys. et Hist. Nat. Genève, **32**, pt. 1, no. 3, p. 31, pl. 23, figs. 5-5e.

Mauritius.

Bathypectinura, gen. nov.

(Greek *βαθός* = deep + *pectinura*, in reference to the characteristic habitat of the group.)

Disc, excepting radial shields, covered above and below by granules, which more or less fully conceal the underlying layer of scales. Radial shields of moderate or small size, bare, but not conspicuous. Oral shields conspicuous, but supplementary oral plates rudimentary or wholly wanting. Arm-spines relatively

few (3-6) and short. Tentacle-scale single and very large; on basal pores of arm supplementary scales of small size and irregular position are occasionally present. No pores between under arm-plates. Genital slits two in each inter-brachial area.

Type-species, *B. lacertosa* (*Pectinura*) Lyman, 1883. Bull. M. C. Z., 10, p. 231, pl. 3, figs. 4-6.

This is a very natural group of large, deep-water ophiurans, all but one of which have been referred hitherto to the genus *Pectinura* in spite of the rudimentary condition of the supplementary oral plates. The *Ophiopeza reducta* of Koehler (1907, Bull. Sci. France et Belgique, 41, p. 283) differs from the other species not only in its elongated radial shields, but also in its coloration, for while they are unicolor (whitish in alcohol or dry), Koehler's single specimen of *O. reducta* shows traces of a variegated disc and annulated arms. Koehler very naturally considers that this coloration would indicate a shallow-water habitat, and if such is the case, *O. reducta* would differ markedly from the other species of the genus in that particular. However, its structural peculiarities appear to necessitate its being placed in this genus, at least until we have further light on its distribution and variability.

Key to the Species of *Bathypectinura*.

Arm-spines 3 or 4.

Radial shields not twice as long as wide; under arm-plates not quadrilateral, the first one wider than long.

Oral shields wider than long; arm-spines longer than $\frac{1}{2}$ arm-joint.

Disc including more than 4 basal arm-joints; upper arm-plates highly arched so that arm-spines appear low down on side of arm *lacertosa*

Disc including not more than 3 basal arm-joints; upper arm-plates not highly arched so that arm-spines do not appear low down on side of arm *elata*

Oral shields longer than wide; arm-spines shorter than $\frac{1}{2}$ arm-joint; disc including more than 4 basal arm-joints *heros*

Radial shields 3 times as long as wide; under arm-plates quadrilateral, the first one longer than wide *reducta*

Arm-spines 5 or 6.

Lowest arm-spine longest, equal to arm-joint *modesta*

Arm-spines subequal, about $\frac{1}{2}$ as long as arm-joint.

Interbrachial areas (orally) densely granulated *conspicua*

Interbrachial areas with many bare plates, surrounded by granules *tessellata*

Bathypectinura lacertosa.

Pectinura lacertosa Lyman, 1883. Bull. M. C. Z., 10, p. 231, pl. 3, figs. 4-6.

Off Grenada, 159 fms.

Bathypectinura elata.

Pectinura elata Koehler, 1906. Mem. Soc. Zool. France, **19**, p. 7, pl. 1, figs. 1-3;
1907, "Travailleur" et "Talisman" Oph., p. 249, pl. 18, figs. 1-3.

Southwest of Canary Islands, 1292-1399 fms.

Bathypectinura heros.

Pectinura heros Lyman, 1879. Bull. M. C. Z., **6**, p. 48, pl. 14, figs. 389-391. 1882,
"Challenger" Oph., p. 16, pl. 23, figs. 7-9.

Off Aru Islands, 800 fms.; off Laccadive Islands, 865-880 fms.; Bali Sea,
northeast of Java, 538 fms.; Strait of Makassar, 1116 fms.

Bathypectinura reducta.

Ophiopeza reducta Koehler, 1907. Bull. Sci. France et Belgique, **41**, p. 283, pl. 10,
figs. 1, 2.

Locality and depth unknown.

Bathypectinura modesta.

Pectinura modesta Koehler, 1904. Oph. "Siboga" Mer Prof., p. 7, pl. 2, figs. 4-6.

Northeast of Java, 183 fms.

Bathypectinura conspicua.

Pectinura conspicua Koehler, 1897. Ann. Sci. Nat. Zool., (8) **4**, p. 322, pl. 6, figs. 36,
37; Oph. "Siboga" Mer Prof., pl. 1.

Gulf of Bengal, 410 fms.; off Sumbawa, Flores and Celebes, D. E. I., 300-
1116 fms.

Bathypectinura tessellata.

Pectinura tessellata Lyman, 1883. Bull. M. C. Z., **10**, p. 230, pl. 3, figs. 1-3.

Off Santa Cruz, Danish West Indies, 451 fms.

Cryptopelta, gen. nov.

(Greek *κρυπτός* = hidden + *πέλιτη* = shield, in reference to the covering of the oral
shields by granules.)

Disc, including radial shields, interbrachial areas, oral shields (except rarely the
central part), adoral plates, and angles of jaws, entirely covered with a close, fine
granulation, which entirely conceals the underlying scales and even extends onto
the bases of the arms. Arm-spines about 7, short and appressed. Tentacle-scale
single. Teeth few, narrow, acute. Oral papillae numerous (16-18 on each jaw),
distal ones wide and blunt, proximal narrow and sharp. No pores between basal
under arm-plates. Genital slits 2 in each interbrachial area.

Type, *C. aster* (*Ophiopeza*) Lyman, 1882. "Challenger" Oph., p. 12, pl. 21, figs.
16-18.

The discovery in the M. C. Z. collection of a new ophiuran, closely related to *Ophiopeza aster* Lyman, has served to emphasize the peculiarities of that species. The two seem to form a very distinct group, the nearest ally of which is probably to be found in the genus *Pectinura* or possibly in the peculiar *Bathypectinura reducta*. They may be distinguished from each other as follows:—

- Upper arm-plates, especially first one, much wider than long, widely separated on last 12–15 arm-joints; arm-spines 6–9, not half as long as joint, blunt, upper much shorter than lowest two *aster*
 Upper arm-plates about as long as wide, first one nearly circular, in contact to very tip of arm; arm-spines 7, half as long as joint, sharp, subequal *granulifera*

Cryptopelta aster.

Ophiopeza aster Lyman, 1879. Bull. M. C. Z., 6, p. 50, pl. 14, figs. 395-397. 1882, "Challenger" Oph., p. 12, pl. 21, figs. 16-18.

Off Cape of Good Hope, 150 fms.; Paternoster Islands, 7 fms.; Sulu Islands, 9–13 fms.

Koehler's statement (Oph. "Siboga" Litt., p. 13) that the "Challenger" specimens were taken near New Guinea is an unaccountable slip, as in both of Lyman's papers the station is given as 142, which was 35° 4' S. × 18° 37' E. Lyman says (l. c.) there are six arm-spines, but the M. C. Z. specimen has seven, and Koehler (l. c.) found seven, eight, and in one specimen nine.

Cryptopelta granulifera, sp. nov.

(Latin *granulum* = a little grain + *fero* = bear, in reference to the unusual granulation of the oral surface.)

Disc pentagonal, 7 mm. in diameter, closely covered by a fine granulation, which, however, is coarser and more distinct than in *aster*, with about 15–20 grains per millimeter. Arms about 25 mm. long, a trifle more than a millimeter broad and less than a millimeter high, distinctly flattened. There is no notch in the disc at the base of the arm, but on the contrary the granulation of the disc conceals the basal upper arm-plates. First (visible) upper arm-plate nearly circular; others about as long as wide, with straight proximal, diverging lateral, and convex distal margins. Interbranchial areas orally completely covered with disc granulation to the very bases of the oral papillae, except that the oral shield containing the madreporic opening is partially bare. Oral papillae 18–22 on each jaw; penultimate widest, almost square; proximal very acute. Teeth 3–4, narrow and very sharp. Under arm-plates squarish, or further out more pentagonal, with rounded corners; first one much longer than wide and very narrow; succeeding ones broader; 7–12 about as wide as long. Arm-spines 7 at base of arm, subequal, acute, half as long as joint. Tentacle-scale single, somewhat longer than wide, rounded. Genital slits conspicuous, 2 in each interbranchial area. Color of disc very pale fawn-brown, becoming yellowish below; arms whitish, with 3–5 broad bands (includ-

ing 2-5 joints) of dull purplish-brown; these bands are not visible on the lower surface.

Mauritius. N. Pike, Collector. One specimen.

This interesting specimen was received at the Museum in 1875 and bears the label "*Ophiopeza fallax*." At first sight it might be mistaken for a young individual of that species, but examination of the oral surface with a lens soon shows how very different it is. Its close resemblance to *Ophiopeza aster* Lyman is obscured by its very different coloration and much more flattened arms.

ASTROPHYTIDÆ.

Conocladus, gen. nov.

(Greek *κῶνος* = cone + *κλάδος* = branch, in reference to the branching arms and the large conical tubercles.)

Disc divided into five radiating wedges by the pairs of radial shields and covered, together with the upper surface of the arms, by an uneven pavement of polygonal, flat granules of very diverse sizes, among which large, conical, or rounded tubercles are irregularly scattered. (In young individuals these tubercles are few and there may be only a single one on each "radiating wedge.") Arms branching dichotomously, with four or more divisions; the distance of the first division from the margin of the disc is about equal to the diameter of the disc. Under surface of disc and arms covered with a pavement of small, rounded granules. Tentacle-scales (or arm-spines) about 4, short, peg-like, and somewhat flattened, terminating in 3-5 minute, glassy points. Mouth-angles with a group of flat, pointed teeth, deep in the mouth, and a few scattered, spiniform, oral papillae along the margins.

In the structure of the disc, though not in its ornamentation, this remarkable genus resembles *Astroporpa* more nearly than it does any of the *Astrophytidae*, but in the branching of the arms it is intermediate between *Trichaster* and *Gorgonocephalus*.

Conocladus oxyconus, sp. nov.

(Greek, *ὀξύς* = sharp + *κῶνος* = cone, in reference to the pointed form of the cones on the disc.) Plate.

Diameter of disc 18 mm. Length of arm about 60 mm.; width of arm near disc 6 mm.; height of arm near disc 4 mm. Radiating wedges of disc separated from each other by 5 deep, very narrow grooves with vertical sides, which meet at centre of disc in a hole or pit scarcely a millimeter in diameter but fully 2 millimeters deep. Each wedge is covered with plates, grains, or granules, usually flat and smooth, sometimes rounded, of very diverse sizes, the largest about a millimeter across. Among these are scattered 5-7 conical tubercles, about 2 mm. high and 1.5 mm. in diameter at the base. The tubercles are smooth at the base but are more or less rough with pits and ridges at the tip. They have no regular arrangement, but one is at the innermost angle of the wedge. The pavement of plates and gran-

ules extends out on the arm so that there is no line of division between the latter and the disc. The large tubercles tend to form a single series on the upper surface of each arm, becoming gradually smaller as they approach the second fork, beyond which they are rarely found. There are about 4 on the basal segment of the arm and about 5 on each of the branches before the first fork. The arms branch about 6 times, the first division being about 20 mm. from the disc; the resulting branches are sometimes equal and sometimes strikingly unequal. Beyond the second or third fork, the branchlets are very slender and are covered by alternating paired half-circles of granules and glassy hooklets, so commonly found in the *Astrophytidae*. The oral surface of disc and arms is covered with small, roundish, flat granules, most numerous on the mouth-angles and bases of the arms. The tentacle pores are small and indistinct; the first pair (not counting those between the mouth-angles) are between the first and second arm-joints and have no protecting tentacle-scales. Each succeeding pore is more or less concealed by a slight ridge on its adoral side, which carries 4 (rarely 3 or 5) short, slightly curved, peg-like spines or scales. Each spine is somewhat flattened and is a trifle widened at the tip where its margin divides into 3-5 little glassy spinelets. Each mouth-angle carries deep in the mouth a cluster of about half a dozen flat, pointed teeth, and along each side of the mouth-slit are 3-5 spiniform oral papillae. The genital slits are prominent, about 2 mm. long. The madreporic plate is single and rather conspicuous, about 2 mm. across. The color (dry) is almost uniformly whitish, becoming more yellowish about the mouth and on the under side of the arms. In a young individual (fig. 3), with the disc 8 mm. across, each radiating wedge carries only a single conical tubercle. The tubercles on the arms are arranged in an almost perfect, single series. All of the tubercles are furrowed and ridged over their entire surface. The arms branch only 3 or 4 times. The color is very light brownish, darkest underneath.

Of this remarkable species the M. C. Z. collection contains three dry specimens. One of these (fig. 3) has been in the collection for many years and bears only the label "*Astrophyton australe?* Young"; there is no indication of locality. The other two were received in exchange from the Australian Museum and are labelled, "*Gorgonocephalus australis* Verrill???. Off Port Jackson, 40-50 fms." The character of the disc shows that these specimens are not *Gorgonocephalus*, but in view of the branching arms it is not altogether strange that they have been referred to that genus. Both of the specimens from Port Jackson were closely embracing the branches of a sponge.

ECHINOIDEA.

CIDARIDAE.

Porocidaris elegans.

Porocidaris elegans A. Agassiz, 1879. Proc. Amer. Acad., 14, p. 198.

A fine series of ten specimens of this species, from off Port Jackson, N. S. W. 250-300 fms., is in the Museum collection. They are remarkably uniform in

their yellowish-brown coloration and in the characters of test, spines, and pedicellariae. Superficially they look very different from the specimens taken by the "Challenger" at nearly the same place (Station 164 a), which are dull reddish in color and have much stouter spines. I do not find, however, any satisfactory specific differences. The Museum now possesses one of the specimens of this species collected by the "Siboga" near Celebes, and one taken by the "Valdivia" near Sumatra, and there seems to be no important difference between them. In size and form, and in length and slenderness of the primary spines, the "Siboga" specimen is remarkably similar to the series of ten from Port Jackson, but it lacks entirely the yellowish-brown coloration. The test is pale dull reddish, and the spines, even secondaries and miliaries, are pure white.

ECHINOTHURIDAE.

Asthenosoma thetidis, sp. nov.

Test rather firm, though greatly flattened in the preserved specimens. Coronal plates, moderately high; in interambulacra, about 20 on actinal side and 25 abactinally, in a specimen 180 mm. in diameter; in ambulacra there are only about 28 actinally and 42 abactinally. Primordial interambulacral plate at peristome very distinct. Ambulacra wide, nearly three-fourths as wide at ambitus as interambulacra. Poriferous areas rather narrow, clearly defined. Primary tubercles abactinally, very few (100-125) and irregularly scattered; actinally, each interambulacral plate carries one or two, but they are arranged in such a way that there are three columns of big tubercles on each side of an interambulacrum, the median area being nearly free from primaries; most of the actinal ambulacral plates, except those nearest the actinostome, carry a large tubercle near the inner end and a smaller one near the interradian end, so that there are four more or less irregular columns of tubercles in each ambulacrum, of which the two median are decidedly the most conspicuous. Secondary and miliary tubercles are comparatively few, and the inner ends of the interambulacral plates, and both ends of the ambulacral plates abactinally, are entirely free from them, so that there are 20 conspicuous, bare areas radiating from the abactinal system to the ambitus. Abactinal system about .17 of the diameter of test; genital plates large (7×7 mm.), roughly triangular, usually not in contact with oculars, but separating the uppermost two pairs of interambulacral plates; genital openings very large, 3 to 4 mm. in diameter, but confined within the plate; ocular plates rather small, about 3 mm. wide by $2\frac{1}{2}$ high; anal plates small, widely separated, about 60 in number. Actinostome about .23 of test-diameter, with 13 or 14 concentric series of ambulacral plates, which diminish so rapidly in size near the teeth that opposite each tooth is a bare, wedge-shaped area 3 mm. wide at base (against the tooth) and about 8 mm. long. Primary spines relatively short, only 15-20 mm. long, even on the actinal surface, where they are tipped with a slender white hoof 3-4 mm. long. Secondary and miliary spines very slender. Pedicellariae not peculiar, very similar to those of *A. oustoni* (Mortens.); both

tridentate and triphyllous are abundant. Color of test deep brown in alcoholic specimens, becoming bright brown when dry; spines, green abactinally, but greenish-brown on the actinal surface; hoofs of the primaries, white.

Off Botany Bay, New South Wales, 80 fms.

An excellent series of ten specimens of this interesting echinothurid are in the M. C. Z. collection. They were received in exchange from the Australian Museum, and are labelled "*Phormosoma hoplacantha*." This is undoubtedly the species to which Mr. Waite refers in his introduction to the reports on the collections of the "*Thetis*," when he says that "in eighty fathoms off Botany Bay, between two and three hundred examples of the rare echinoderm *Phormosoma hoplacantha* Wy. Thompson, were hauled on board. This find was specially interesting as the animal had previously been taken only by the 'Challenger' at the minimum depth of 410 fathoms."

The relationship of *A. thetidis*, however, is not with the deep-water species like *A. hoplacantha*, but with the shallow-water forms like *Asthenosoma orstoni* (Mortens.), to which it seems to be nearly allied. It may be distinguished from that Japanese species, however, by the larger and less numerous primary tubercles, the much higher actinal coronal plates, the more regular arrangement of the actinal interambulaeral tubercles, the much wider ambulacra, and the very different color. I take pleasure in associating with this interesting species the name of the vessel to which we owe its discovery.